ISR and FSR studies for top events

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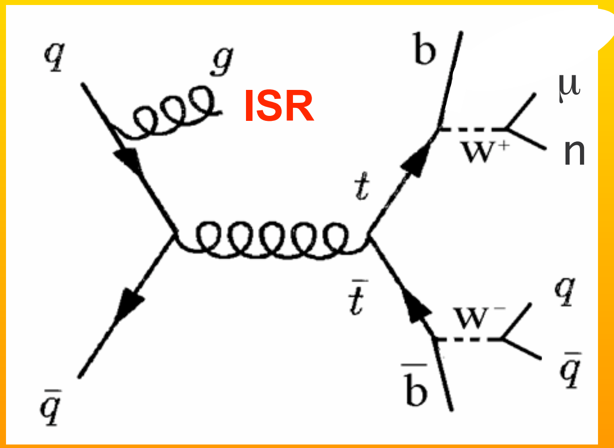
Summary

- ISR and FSR in top events
- What we have been doing
- What is done in CDF
- What we should do

The Top Quark

- M_{top} = 172.7±2.9 GeV/c^2 (current world average)
  - by end of Run II: reduce uncertainty on M_{top} to <1.5 GeV
- Extra jets originating from the incoming partons and outgoing partons affect the measurement of Mtop when they are misidentified as jets from the final state partons or change the kinematics of the final state partons.



Systematic uncertainty due to this effect was usually assigned using MC events where ISR (and FSR) are switched on and off

Non physical!

- ISR and FSR are controlled by the same DGLAP evolution equation that tells us the probability for a parton to branch (splitting function) and is driven by Q^2, Λ_{QCD}, and pdf.

Old ISR and FSR evaluation

- In the past, following CDF

Drell Yan processes

Nowadays, CDF determines the systematic uncertainty due to ISR using Drell-Yan events.

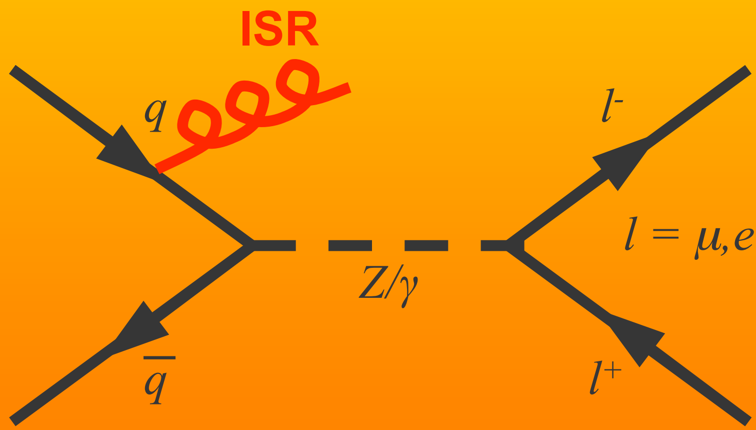
Advantages of Drell-Yan events are twofold:

- due to the dilepton final state, there are no final state or FSR jets
- DY dileptons are produced by the $q\bar{q}$ annihilation process, as are most (~ 85%) $t\bar{t}$ pairs at the Tevatron (not the LHC case)

Very similar to top production process

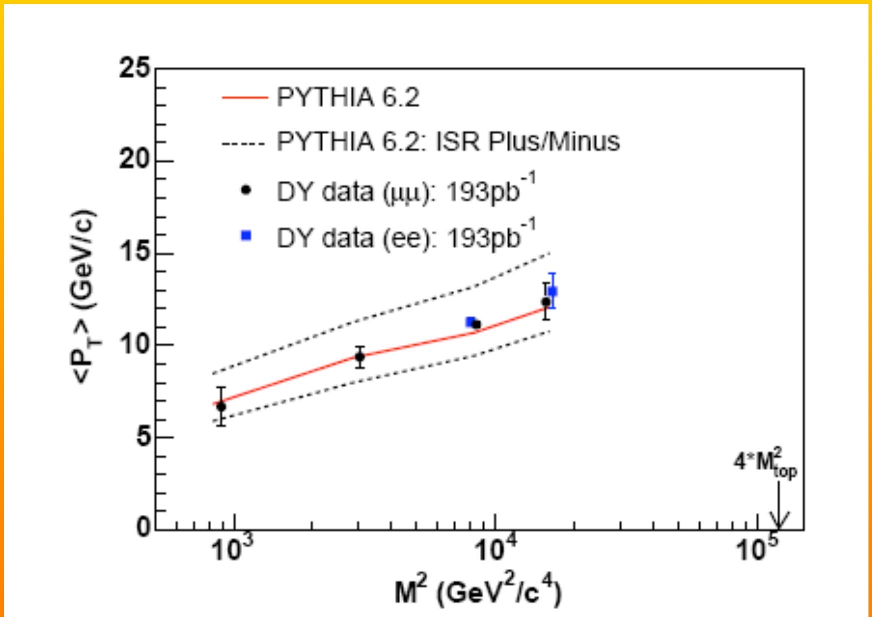
Dominated by q-qbar annihilation, but in lower mass region

Z decays into lepton pairs (**e**, μ, or τ pair)



New ISR uncertainty estimate

- The logarithmic dependence of some observables (average P_T of the dilepton system, number of soft jets etc) on the scale (M(ll)) is measured and it is found that both Pythia (CDF tuned version) and HERWIG describe the ISR activity well over a wide range of DY mass regions.



1) The logarithmic slope is fitted
2) The results of the fit are used to define a 1σ range of uncertainty
3) This is used to generate different MC samples (ISR up and ISR down) using some tunable physics MC parameters that can be varied:

PARP(61) = Λ_{QCD} in ISR shower

PARP(67)= K factor for the starting Q^2 scale of the ISR shower

New ISR evaluation II

- By extrapolation the ISR effect is then estimated at top pair production energies.
- Two ISR systematic Monte Carlo samples ($+1\sigma^{ISR}$ and $-1\sigma^{ISR}$) are produced using PYTHIA, by varying the value of QCD and scale factor, K to the transverse momentum scale for ISR showering.
- The parameters used are
  - QCD(5 flavors) = 292 MeV, K = 0.5 for + $1\sigma^{ISR}$
  - QCD(5 flavors) = 73 MeV, K = 2.0 for −1 $1\sigma^{ISR}$
- The signal and background p.d.f.’s used in the analysis remain unchanged.
- The shift in the fitted top quark mass is taken as the systematic uncertainty associated with the FSR effect.

Evaluation of the ISR/FSR effects

- To evaluate the uncertainty due to ISR/FSR, the relevant parameters are varied by ±1σ, and new 178 GeV/c2 $t\bar{t}$ signal and background Monte Carlo templates have to be produced by performing event selection and mass reconstruction on the modified samples.

- The signal and background p.d.f.'s used in the analysis remain unchanged.

- The shift in the fitted top quark mass is taken as the systematic uncertainty associated with the FSR effect.

LHC case

- The slope found using DY events in CDF can be used for LHC when the qq initial state is the dominant process.
- Where other states are dominant, like gg in top production a similar approach can be used using a different FSR-free process, for example $gg \rightarrow \gamma\gamma$
- To this extent a good understanding of the planned triggers is necessary to have the data necessary to span various mass regions.

Summary

- CDF finds that the Pythia MC describes the ISR activities reasonably well over a wider rage of the DY mass regions in P_T(dilepton), N_{jets}, and $\Delta\phi$(dilepton) distributions

- A good logarithmic dependence on M^2(dilepton) is observed in the average P_T of the dilepton: for two different version of the software the results of the fit are in excellent agreement:
  - $\langle P_T \rangle = (-7.09 \pm 2.69) + (2.01 \pm 0.30)*\log(M^2)$
  - $\langle P_T \rangle = (-6.43 \pm 3.10)+(1.96 \pm 0.35)*\log(M^2)$
  - Can constrain ISR activities at top mass production region, $M \sim 2*M_{top}$

Future Plans

- Future plans:
  - Include full dataset in very low mass region
  - Study Q^2 dependence of N_{jets} and $\Delta\phi$(dilepton)
  - Produce MC samples with $\pm1\sigma$ of ISR systematic based on our results

Analysis

- Parameters of interest:
  - *P_T(dilepton)*
  - *N_{jets},*
  - *$\Delta\phi$(dilepton)*

  (sensitive to extra gluon radiation) in different DY mass regions.